R2E annual meeting

Radiation tolerant development

Vacuum

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On behalf of TE-VSC

CERN
Vacuum, Surfaces & Coatings Group
Technology Department

VSC R2E Work Package

sub-WP1 (R2E):

Task 1: Active gauges in the arcs;

- Task 1.2: Active piezo gauges in the arcs;

Task 2: Active gauges in the LSS;

Task 3: 24 VDC local power supply for fixed pumping groups.

sub-WP2 (R2M):

Task 1: O-ring seals;

Task 1.2: F6 and F14 O-ring seals under compression;

Task 2: Permanent bake-out components;

- Task 2.2: New bake-out jackets for LHC bellows close to collimators;

Task 3: NiTiNb SMA (Shape Memory Alloy) connectors;

- Task 3.2: SMA (Shape Memory Alloy) connectors set-up in TDC2;
- Task 3.3: SMA set-up in CHARM;
- Task 3.4: SMA set-up in IRRAD;

Task 4: Primary and turbo pumps;

Task 5: Micro switches and distributors for sector valves;

Task 6: Passive penning gauge and its HV cable under high HEH

- Task 6.2: Induced current in HV cables under radiation;
- Task 6.3: Radiation induced cables aging impact on their electrical performance;

Task 7: Silicon rubbers and polyurethanes clamps, vacseal & epoxies;

Task 8: Piezoelectric venting valve;

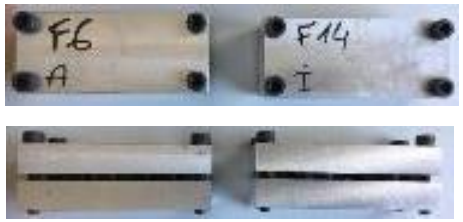
Task 9: Passive piezo resistive gauge in the LSS & dump lines.

Task 10: Stepper motor & bearing

Identified tasks (2016)
Scope extension & new tasks (2017)
Scope extension & new tasks (2018)

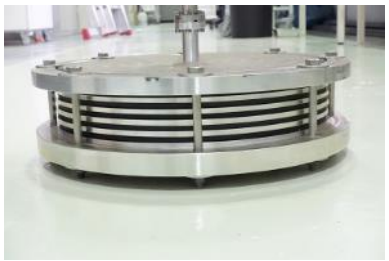
O-ring seals

- Used for leak tightness of the insulation vacuum (e.g. magnets interconnexion)
- Study special EPDM formulation (F6, F14) to be used in high radiation areas
- Facility: BGS (Gamma)
- Dose steps: 50kGy; 250kGy; 500kGy; 1MGy; 5MGy; 10MGy



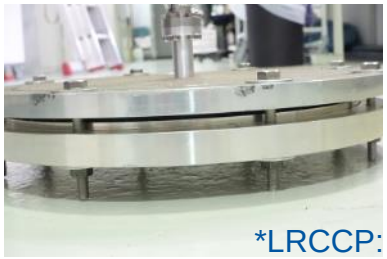
- Samples under compression
- Samples sent to LRCCP* for mechanical characterization
- LRCCP's results in Q1 2019

Type A: 3 levels of compression



- O-Rings under compression + vacuum
- Test results on all the samples:
  - Up to 1 MGy: remains leak tight
  - 5 MGy: small leak ~10-4 mbar.l.s-1
  - 10 MGy: big leak + oil deposition
- Samples sent to LRCCP*
- LRCCP's results in Q1 2019

Type B: Nominal compression



*LRCCP: Laboratoire de Recherches et de Contrôle du Caoutchouc et des Plastiques

Bake-out parts

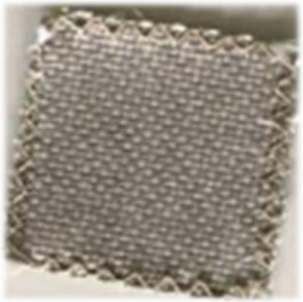
- Permanently installed bake out system in high radiation areas (e.g. collimators)
- Study the radiation resistance of existing and new bake out parts
- Facility: BGS (Gamma)
- Dose steps: 500kGy; 1MGy; 5MGy; 10MGy; 15MGy

Power plug

- Received the 500kGy; 1MGy; 5MGy; 10MGy samples
- Tests results on 500kGy, 1MGy and 5MGy samples:
  - Stitching wire maintains its strength
  - @ 5MGy Aerogel is becoming harder, layers detach easily
  - No effect on power plug
- 10MGy and 15MGy samples tests in Q1-Q2 2019

Aerogel

Fabric

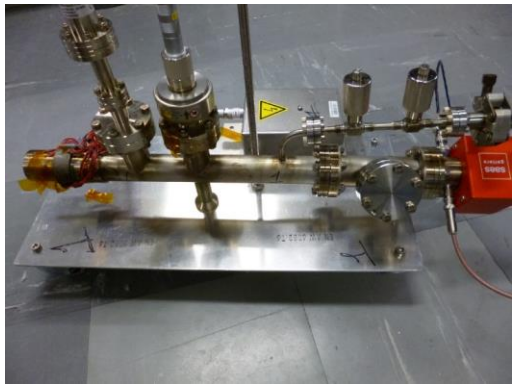


Stitching wire

SMA (Shape Memory Alloy)

- Remote (un)clamping in high radiation areas
- Investigate if atomic structure alteration can affect its properties
- Facilities: TDC2 (Mixed field); CHARM (Mixed field); IRRAD (Proton)

Test set-up used in TDC2



Preliminary results

- Absorbed dose ~ 250 kGy
- No significant variation of the pressure/leak rate during the exposure
- No significant variation of the strain (contact pressure) signals

Test set-up used in CHARM

Preliminary results

- Absorbed dose ~ 250 kGy
- No significant variation of the strain (contact pressure) signal

Test set-up used in IRRAD

Preliminary results

- Absorbed dose ~ 4 MGy
- No significant recovery stress variation during the exposure

Turbo pumps

- Maintain High Vacuum for insulation vacuum
- Identify radiation induced failures of the pump
- Facility: BGS (Gamma)
- Dose steps: 500kGy; 5MGy; 15MGy

500kGy

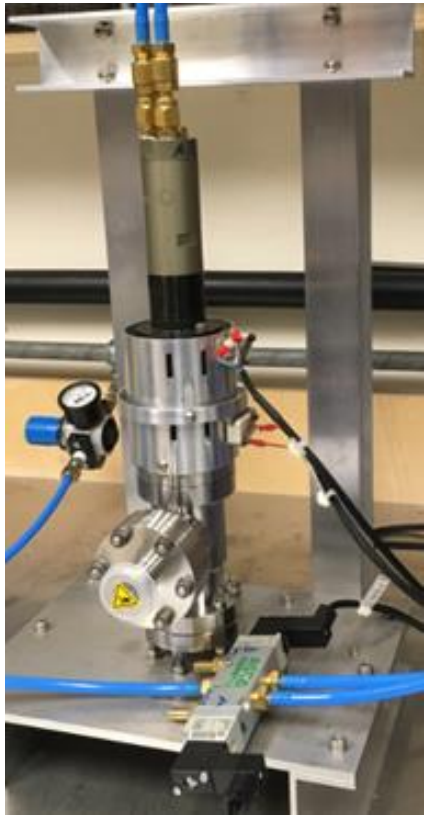
5MGy

- Received 500kGy, 5MGy irradiated turbo pumps
- Samples received chocks during transport
- No tests performed yet
- 15 MGy sample will be received in Q2 2019
- Tests foreseen in 2019:
  - Visual inspection
  - Functional test (nominal speed)
  - emf measurement
  - Leak test (body)
  - Oil analysis

Pneumatic devices for vacuum valves

- Actuate and get statuses of vacuum elements (new VAX modules in ATLAS/CMS)
- Identify radiation induced failures and validate the best device (material) choice
- Facility: BGS (Gamma)
- Dose steps: 500kGy; 1MGy; 5MGy

Pneumatic motor

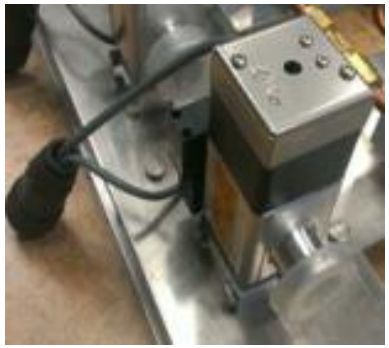


Pressure reducer

Position indicators & micro switches

Pneumatic distributors

Pneumatic angle valves



- Samples and test bench ready
- Irradiation to be performed in Q1 2019
- Tests foreseen after Q2 2019:
  - Visual inspection
  - Functional test (cycle tests)
  - Leak tests

HV cables under high HEH & cables aging

- Used for vacuum instrumentation
- Study the radiation effects on electrical & mechanical properties
- Facilities: CHARM (mixed field); IONISOS (Gamma)
- Dose steps: 25kGy; 100kGy (IONISOS)

25kGy

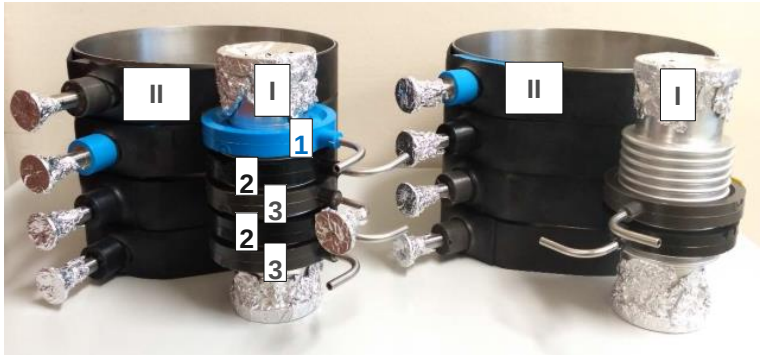
100kGy

- Received 25kGy, 100kGy irradiated cables from IONISOS
- No tests performed yet, tests foreseen in 2019:
  - Visual inspection
  - Chemical analysis
  - Electrical tests (HV isolation)

Silicon rubbers & polyurethanes clamps

- Provide fast temporary solution for mitigation of leak effect (differential pumping)
- Identify the best material choice (Silicone rubber, polyurethane)
- Facilities: BGS (Gamma)
- Dose steps: 500kGy; 1MGy

I. Bellow clamp in ATLAS
II. Short straight clamp in CMS



3 different material under test

1. Silicone rubber, Xiameter RTV-4136-M
2. Black PU, Axson RE 11501/1020
3. Grey PU, Axson UR 5803/58630

Irradiation tests results:

- Minimum reachable pressure:
  - not affected for Black/Grey PU
  - 1 decade worst after 1MGy with Silicone rubber
- Leak rate:
  - Not affected for Black/Grey PU
  - 2 decades worst after 1MGy for Silicone rubber
- Mechanical properties:
  - Possible to disassemble Black/Grey PU without breaking the clamps
  - Silicone Rubber broke while disassembling as observed during YETS

Piezoelectric & Piezo-resistive vacuum devices

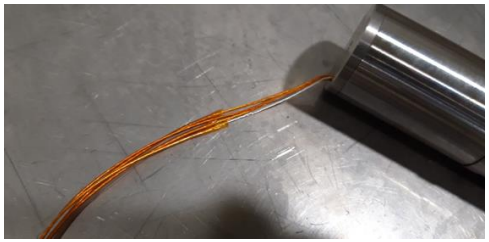
- Piezoelectric valve: used to vent vacuum system
- Piezo-resistive gauge: used in the LHC for insulation vacuum measurement (LSS)
- Facilities: to be defined
- Dose steps: to be defined

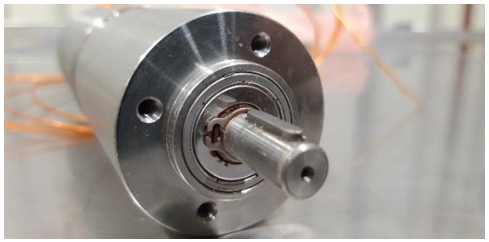
- Irradiation tests results from other users:
  - Piezo-electric motor for collimation system
  - Piezo-resistive gauge for cryogenics system

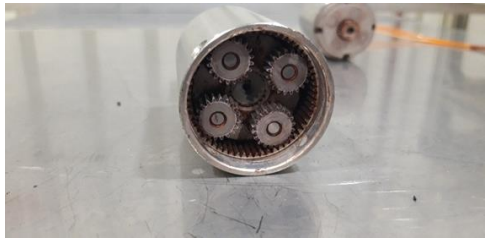
Stepper motor & bearings

- Affects the retractable support system used for the VT vacuum chamber in ATLAS
- Facility: BGS (Gamma)
- Dose steps: 5MGy; 1MGy

- Pre-Post irradiation tests: current/torque, electrical properties, temperature measurements, grease analysis
- The system is stuck after 5MGy irradiation:
  - Peeling of kapton insulation on wires
  - Rust between shaft and bearing occured
  - Change of grease properties
- Further tests on-going (electrical)
- Need for a second irradiation up to 1MGy (10 years of operation)







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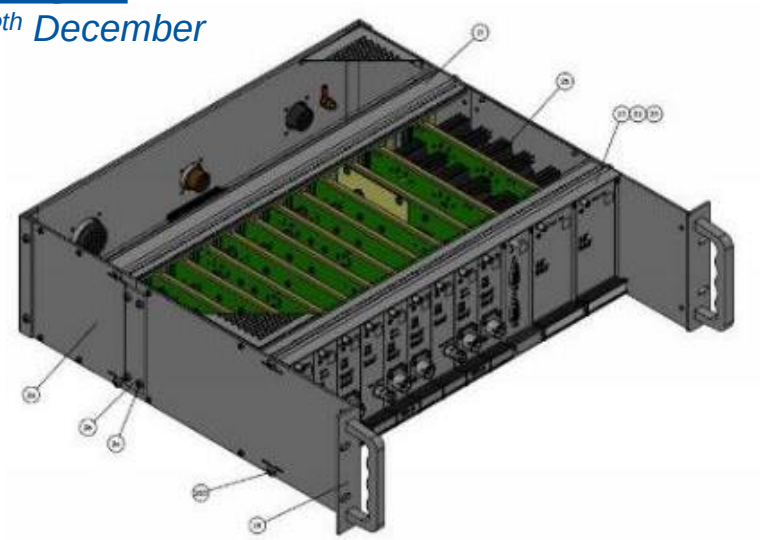
Gauge electronics in the ARCs & DS

Radiation Tolerant Conditioning Electronics for Vacuum Measurements
*By **N. Chatzigeorgiou***
Wednesday 12th December



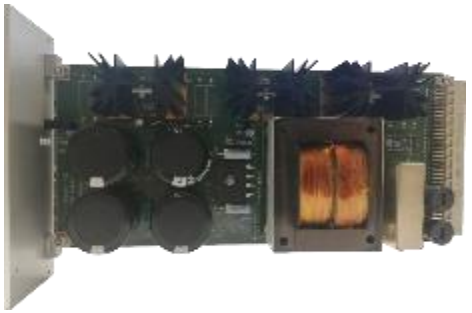
- Pre-series received
- All active components received (batches)
- Full DS production foreseen during Q1 2019
  - 54x Piezo
  - 20x Pirani + Penning
  - 72x Power Supplies
  - 49x crates + mini-racks
- Electronics in the ARCs will be changed in LS3

Penning

Pirani

Piezo

Power Supply



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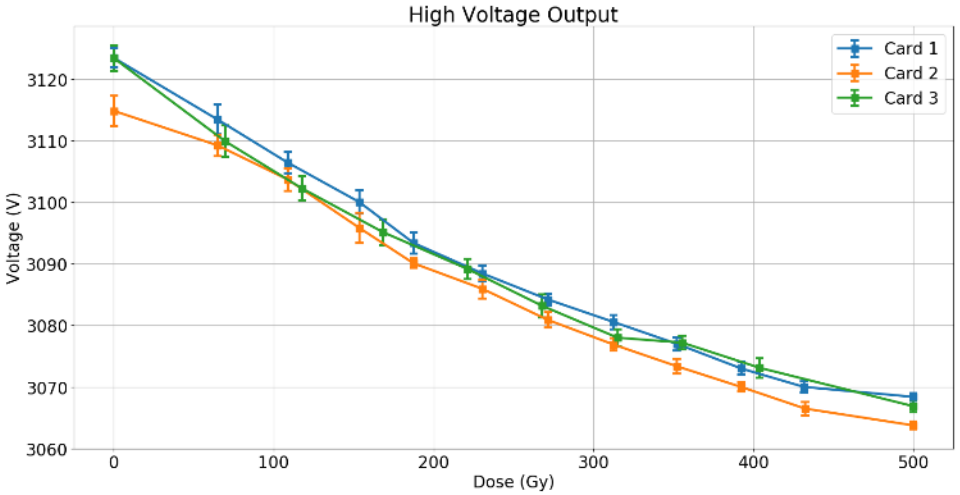

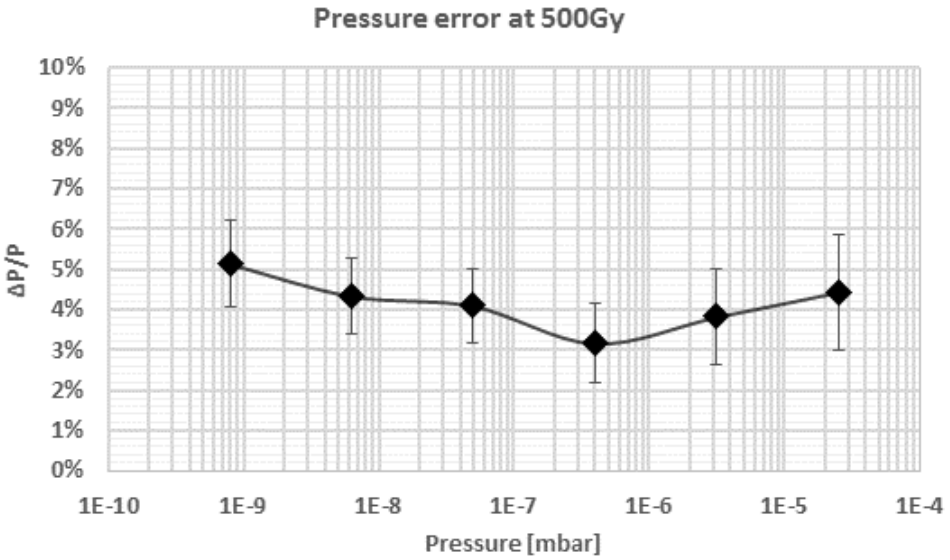

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Pirani

Piezo

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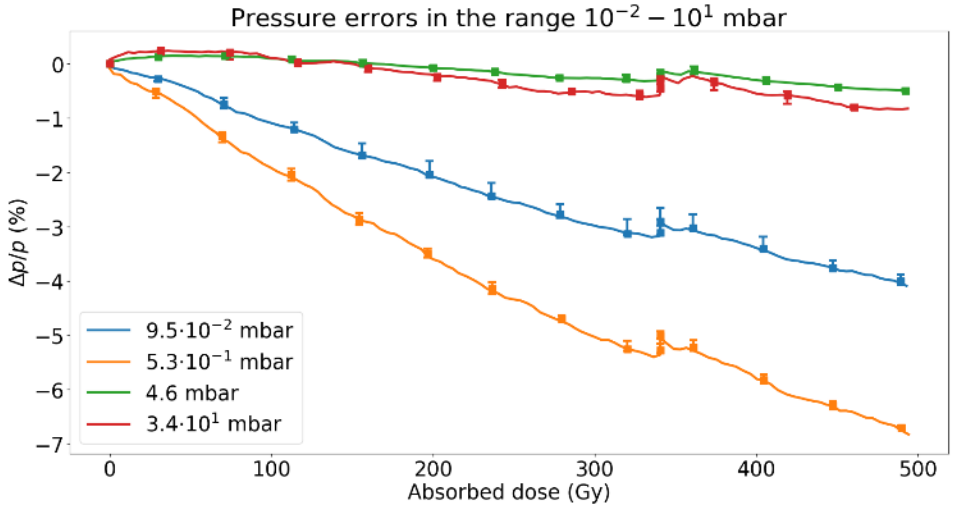

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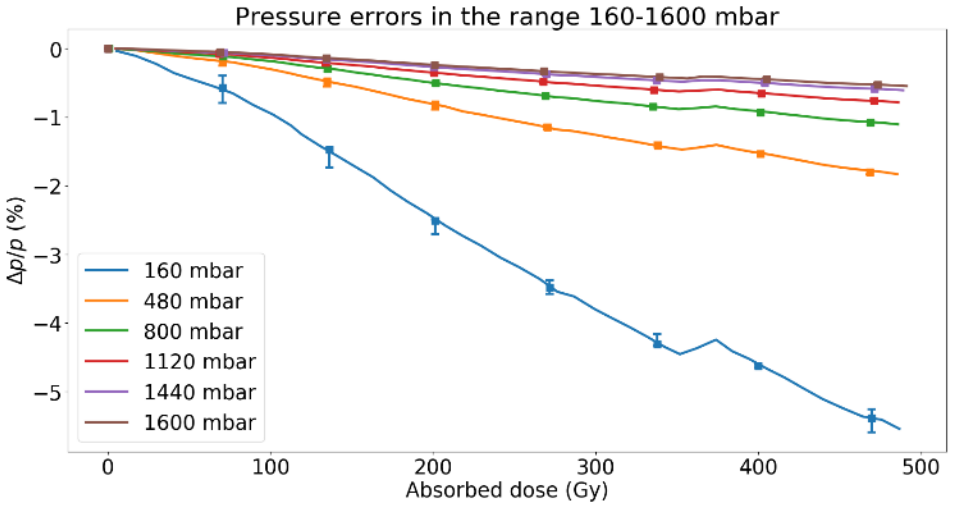

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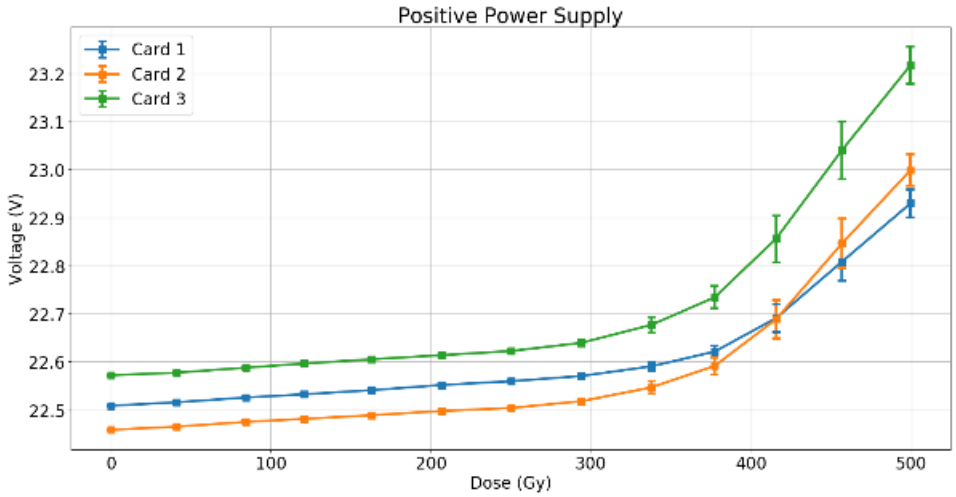

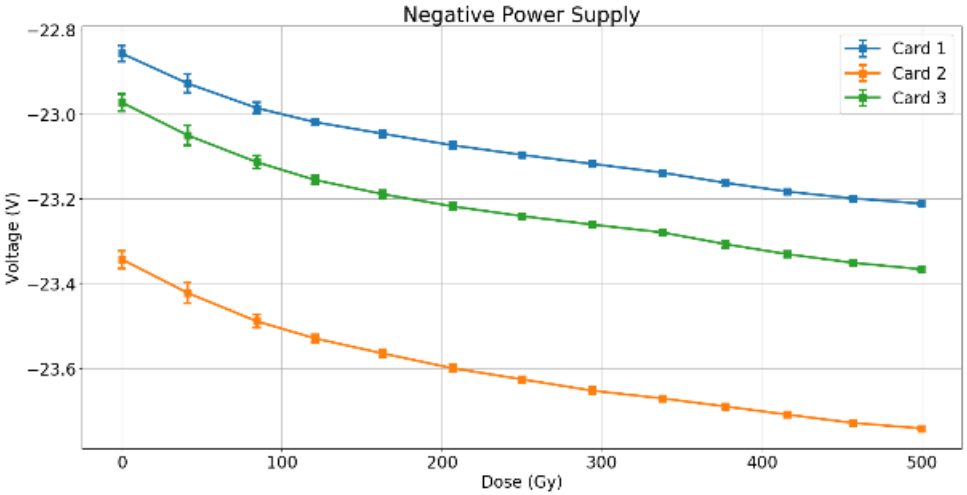

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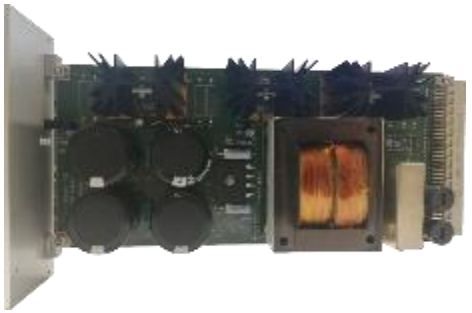
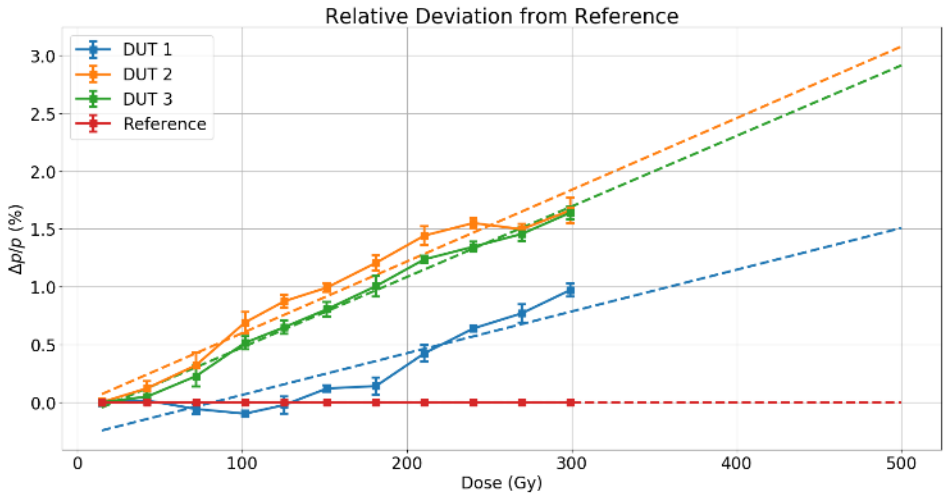


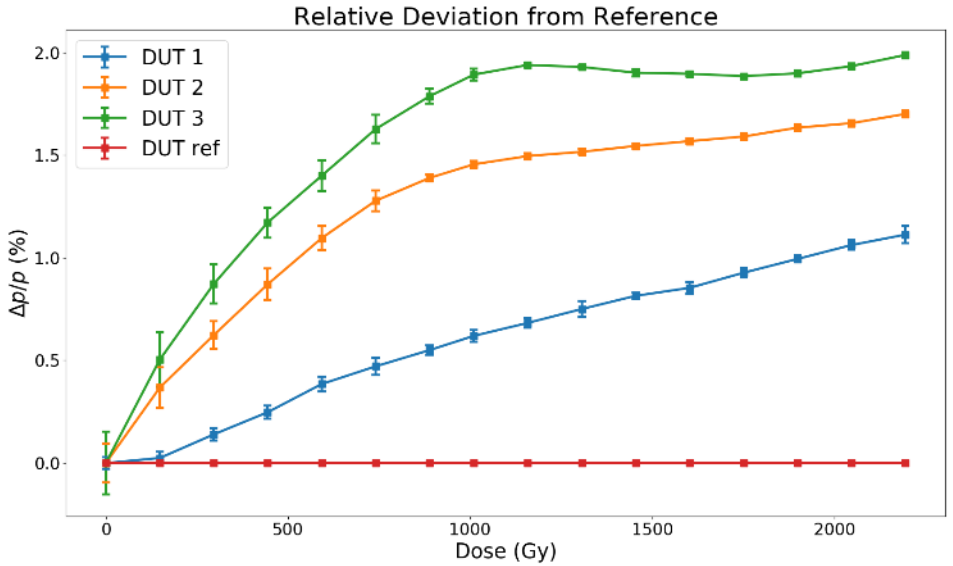
Active piezo-resistive gauges - CHARM

- Installed in the LHC ARCs (insulation vacuum)
- 3 irradiated gauges + temp. measurement
- 1 reference gauge + temp. measurement
- Dedicated control rack
- Absorbed dose ~320 Gy
- < 3 % Pressure relative error



Active piezo-resistive gauges - Co60

- Installed in the LHC ARCs (insulation vacuum)
- 3 irradiated gauges + temp. measurement
- 1 reference gauge + temp. measurement
- Dedicated control rack
- Absorbed dose ~2.4 kGy
- < 2% Pressure relative error



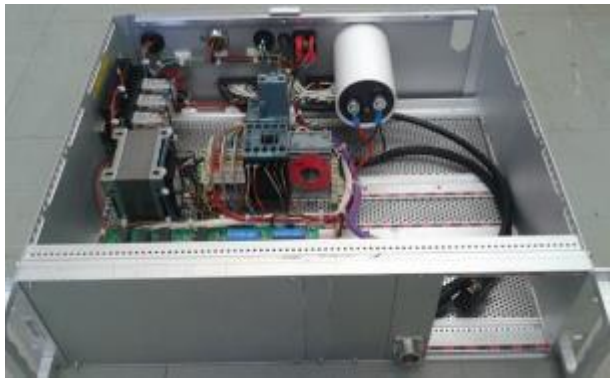
Local powering of fixed pumping groups

- **R2E motivation**: remove sensitive components from local powering crates for fixed pumping groups in the LSS.

- Removal of 2 bipolar transistors (regulated => un-regulated 24VDC)

- New functionalities (needed also in the ARCs)
  - Primary pump passive current measurement
  - Thermal relay remote reset for the primary pump
  - Pressure switch protection

- **Crates modification during LS2:**
  - **102 in the LSS** for QRL, SA & IT and MKB
  - **96 in the ARCs** for QRL and Magnets



Involved people in TE-VSC

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TE/VSC/VSM
V. Baglin, R. Kersevan

Summary

R2M

- The 5MGy campaign in BGS beginning of 2019 is important to complete most of our material irradiation test
- SMA and HV cables are still subject to further irradiation tests (R&D) in 2019 and beyond

R2E

- Radiation tolerant electronics will be installed in the DS areas during LS2
- Batch verification (PSI) for ARCs production (LS3 installation) should start already during LS2
- Modification of local powering crates for fixed pumping groups will be performed during LS2

Thanks to all the people involved!